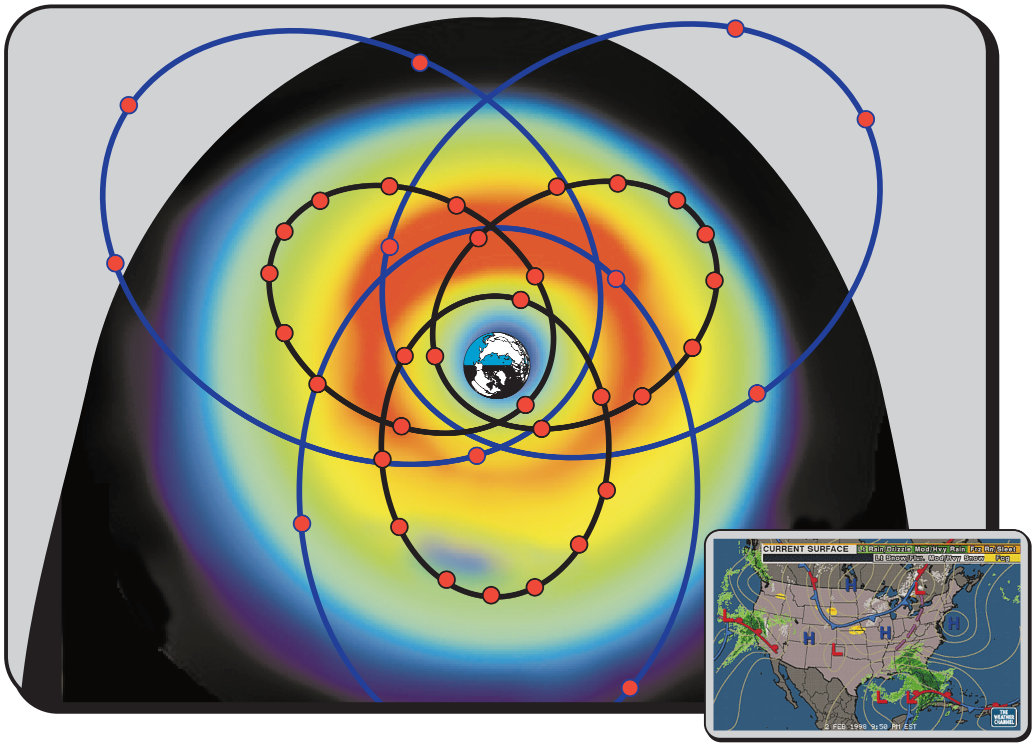
THE ORION CONSTELLATION MISSION



What? A large-scale, time-dependent picture of the particles and fields in the inner magnetosphere.

Why? There has been a breakdown in the classical picture of the inner magnetosphere (e.g. ring current injection, relativistic electron acceleration, electric field penetration). A constellation mission could completely and effectively cover this region and provide science closure.

Mission Description

- 3 inner “petal” orbits (≈2x6.5 R_E) with 10 satellites each and 3 outter “petal” orbits (≈2x12 R_E) with 4 satellites each.
- Orbits maintain uniform coverage of inner magnetosphere, near-earth tail, and magnetopause independent of precession.
- Instruments: Magnetometer, Plasma Analyzer, Energetic Particles, (with maximum ion composition information)

Fundamental Question

What are the origins and dynamics of global magnetospheric particle and field structures?

Science Objectives

- To create time-dependent maps of the inner magnetosphere, near-earth tail, magnetopause, boundary layers, and near upstream solar wind.
- To fully specify and understand the space environment where spacecraft and astronauts work.
- To discover the origin and dynamics of magnetospheric particle populations
- To derive the global, time-dependent magnetic and electric fields.
- To determine the development and evolution of magnetic storms.

Measurement Strategy

- The large-scale equatorial magnetic field is directly measured.
- An independent measurement of the magnetic field - integrated along particle drift paths - is obtained from the energetic particle phase space density contours.
- The large-scale electric field is obtained in a similar way using the ExB drift of lower-energy particles in combination with the derived magnetic field using the fundamental conservation of ‘invariants’ along a drift path.
- Direct measurement origin and dynamics of global particle structures such as the ring current, the relativistic electron radiation belts, the plasmasphere and detached/extruded plasmaspheric populations.
- A global synthesis of the response of the inner magnetospheric particles and fields to geomagnetic disturbances originating on the Sun.

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Recent NASA missions such as CRRES and POLAR have changed the our understanding of the inner magnetosphere. The electric field, even in an average sense, has been found to be quite different from the standard model and the cross-tail electric field has been found to penetrate to very low L-shells. During storms, the magnetic field has been found to be both more dynamic and more asymmetric than previously imagined. The radiation belts have been shown to be highly dynamic with relativistic electron fluxes being enhanced more than a thousandfold in mere minutes.

Although local measurements have provided insight into the processes that operate in the inner magnetosphere they have been unable to adequately describe the origins and dynamics of global magnetospheric structures – particularly during disturbed conditions. The main phase of a geomagnetic storm lasts only a few hours, less than a typical orbital period. Large day/night and dawn/dusk asymmetries in the inner magnetosphere further complicate the global specification of the particles and fields.

The Inner Magnetosphere Constellation Mission is designed to provide "maps" of this important region in order to understand the origins and dynamics of global magnetospheric structures. Using relatively simple magnetometers and particle detectors on a moderate-sized constellation (≈42 satellites) it is possible to provide a complete, time-dependent picture of the magnetic fields, electric fields, and particle populations in the inner magnetosphere.

In this mission concept the particle measurements are used along with the in situ magnetometer measurements to remotely sense the global electric and magnetic field patterns. Energetic particles with 90° pitch angles drift on contours of constant equatorial magnetic field. Thus the particle motion essentially integrates along the drift path while the magnetometer measurements provide local 'ground truth'. By determining the 2D contours of constant phase space density at different pitch angles and different energies the global magnetic field is uniquely specified.

Energetic particles are relatively insensitive to convective (E$\times$B) drifts while the motion of lower-energy particles are strongly controlled by the electric field. Thus, knowing the large-scale magnetic field, the same drift-integrating technique can be applied to lower energy particles to uniquely determine and map the global electric field.

At the same time the Inner Magnetosphere Constellation Mission will directly measure the charged particle populations in the magnetosphere including the plasmasphere (and associated 'tails' or detached 'blobs'), the ring current (with full asymmetries), and the radiation belts (and their origins).

The Inner Magnetosphere Constellation is the "Space Weather' Mission. Maps of the inner magnetospheric particle populations and the fields that control their dynamics has important practical as well as scientific benefit. The vast majority of commercial and military satellites operate at or inside geosynchronous orbit where radiation damage and spacecraft charging are of serious concern. Space weather is also of concern for construction and operation of the International Space Stations whose low-altitude, but high-inclination orbit takes it through the 'horns' of the radiation belts.

By analogy with terrestrial weather specification and modeling we know that useful maps of dynamic systems rely more heavily on global coverage than on sophisticated instrumentation. The Inner Magnetosphere Constellation Mission is designed with this principle firmly in mind. The resulting 'space weather maps' will provide our first pictures of both the particles and fields that comprise the magnetosphere and will reveal the origins of magnetospheric structures and their response to the changing sun.